Data inputs for the African penguin population model

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# Introduction

This document contains various data series proposed to be used as inputs in further penguin modelling work. Most series are updated versions of those appearing in Appendix A of Robinson *et al*. (2010). Note that information found in Tables 1, 3–5 and 7–8 is as agreed for use by the Island Closure Task Team (Robinson and Butterworth 2010a).

It is important that consensus is reached urgently in the PWG regarding their inputs, and that only such “consensus” inputs will be used in any analyses presented to the international review workshop over November 29 to December 3. The reason is that if results from different models differ, one wants to be clear that this is a result of alternative methodologies rather than different data inputs. Otherwise the limited time of the reviewers will be wasted.

# Penguin tag data

Tag data have recently been used to help determine penguin adult survival more precisely (Robinson and Butterworth 2010b). These 14243 records (which, for obvious reasons, are not listed here) give the re-sighting histories (alive and dead) of penguins for the years 2001–2008. The birds list includes birds from all South African regions, banded as both adults and juveniles, from as long ago as 1972.

# Immigration and emigration

In a study of penguins banded as chicks between 1978 and 1999, Whittington *et al*. (2005) found that 2% of those re-sighted after fledging settled to breed at non-natal colonies. Immigrants were thought to be almost exclusively first-time breeders. A net movement of birds was observed from Dyer Island to the west (Stony Point, Boulders, Robben Island and Dassen Island) and from Namibia (mostly to Dassen Island). Note, however, that the number of re-sightings is very low. It is thought that penguins may choose to commence breeding away from their natal colony in order to take best advantage of the distribution of food resources at the time (Crawford 1998). Birds were also observed moving in both directions between Robben Island and Dassen Island. Since these colonies are only 50 km apart, food availability is unlikely to be the driving force in these cases.

# Age at first breeding

African penguins have been observed breeding for the first time in their third year, but most often birds commence breeding aged between 3 and 7 years (Whittington *et al*. 2005). Other studies have found that most penguins commence breeding aged 3 to 5 years (Randall 1983, Crawford *et al*. 1999). Birds are thought to breed at younger ages when food is more abundant.

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# Tables

Table : Annual moult count estimates of penguins in adult and immature plumage at Robben and Dassen Island. Counts take place from 1 July to 30 June at approximately two-week intervals. See Robinson and Butterworth (2010c) for details of how the individual counts have been aggregated. Note that the 2009/2010 moult season is labelled here as 2010.

|  |  |  |
| --- | --- | --- |
|  | **Robben Island** | **Dassen Island** |
|  | **Adults** | **Immatures** | **Adults** | **Immatures** |
| **Year** | **Number** | **CV (%)** | **Number** | **CV (%)** | **Number** | **CV (%)** | **Number** | **CV (%)** |
| 1989 | 3468 | 8.3 | 800 | 19.7 |  |  |  |  |
| 1990 | 3397 | 8.5 | 860 | 18.4 |  |  |  |  |
| 1991 | 4724 | 6.1 | 899 | 17.6 |  |  |  |  |
| 1992 | 4939 | 5.8 | 1562 | 10.1 |  |  |  |  |
| 1993 | 6544 | 4.4 | 1631 | 9.7 |  |  |  |  |
| 1994 | 7915 | 3.6 | 1574 | 10.0 |  |  |  |  |
| 1995 | 7933 | 3.6 | 1369 | 11.5 |  |  | 1398 | 6.7 |
| 1996 | 6674 | 4.3 | 1407 | 11.2 | 12372 | 2.8 | 1767 | 6.9 |
| 1997 | 7300 | 3.9 | 2285 | 6.9 | 12950 | 2.6 | 4940 | 6.1 |
| 1998 | 8556 | 3.4 | 2381 | 6.6 | 16195 | 2.2 | 3374 | 4.4 |
| 1999 | 9501 | 3.0 | 2739 | 5.8 | 21531 | 2.6 | 8324 | 3.6 |
| 2000 | 11694 | 2.5 | 2811 | 5.6 | 25174 | 2.9 | 8399 | 4.4 |
| 2001 | 12883 | 2.2 | 2425 | 6.5 | 26175 | 2.9 | 6720 | 4.8 |
| 2002 | 12362 | 2.3 | 2719 | 5.8 | 25767 | 10.2 | 8305 | 5.7 |
| 2003 | 14469 | 2.0 | 3571 | 4.4 | 25177 | 5.8 | 5680 | 8.5 |
| 2004 | 16975 | 1.7 | 3327 | 4.7 | 16642 | 5.4 | 3915 | 7.4 |
| 2005 | 12442 | 2.3 | 2511 | 6.3 | 17385 | 3.7 | 5006 | 7.1 |
| 2006 | 7660 | 3.8 | 2683 | 5.9 | 11377 | 3.9 | 2186 | 6.8 |
| 2007 | 6453 | 4.5 | 1911 | 8.3 | 7729 | 4.1 | 1719 | 7.6 |
| 2008 | 5157 | 5.6 | 1387 | 11.4 | 2160 | 14.7 | 618 | 23.5 |
| 2009 | 3745 | 7.7 | 1808 | 8.7 | 420 | 18.5 | 76 | 36.8 |
| 2010 | 4430 | 6.5 | 1754 | 9.0 | 340 | 22.6 | 124 | 33.4 |

Table : Number of adult and immature penguins moulting at Dyer Island (provided by R. Crawford).

|  |  |  |
| --- | --- | --- |
| **Year** | **Adults** | **Immatures** |
| 2000 | 4578 | 266 |
| 2001 |  |  |
| 2002 | 4216 | 407 |
| 2003 |  |  |
| 2004 | 6176 | 237 |
| 2005 |  |  |
| 2006 | 3348 | 161 |
| 2007 | 2944 | 178 |

Table : Published nest counts (Underhill *et al*. 2006) with updates provided by R. Crawford.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Robben** | **Dassen** | **Dyer** | **Boulders** |
| 1987 | 476 | 4588 |  | 7 |
| 1988 | 849 |  |  | 34 |
| 1989 | 829 | 8428 |  | 38 |
| 1990 | 1278 |  | 8349 | 54 |
| 1991 | 1879 | 9012 | 6115 | 131 |
| 1992 | 2027 | 7563 | 7579 | 158 |
| 1993 | 2176 | 7299 | 2374 | 241 |
| 1994 | 2799 | 9389 | 4649 | 359 |
| 1995 | 2279 | 9792 | 4260 | 366 |
| 1996 | 3097 | 9502 | 3279 | 416 |
| 1997 | 3336 | 8740 | 2745 | 726 |
| 1998 | 3467 | 10918 | 1963 | 555 |
| 1999 | 3808 | 15155 | 2363 | 906 |
| 2000 | 5407 | 17042 | 2220 | 949 |
| 2001 | 6247 | 21410 | 2088 | 1054 |
| 2002 | 7099 | 22681 | 2145 | 1083 |
| 2003 | 5968 | 20196 | 1929 | 1033 |
| 2004 | 7798 | 24901 | 2216 | 1196 |
| 2005 | 7152 | 22687 | 2053 | 1227 |
| 2006 | 3697 | 13283 | 2057 | 1075 |
| 2007 | 5935 | 11785 | 1513 | 824 |
| 2008 | 2234 | 5719 | 1605 | 913 |
| 2009 | 2415 | 5145 | 1260 | 704 |
| 2010 | 2628 | 4929 | 1561 | 933 |

Table : Active and potential nests (compiled by R. Crawford).

|  |  |  |
| --- | --- | --- |
|  | **Robben Island** | **Dassen Island** |
| **Year** | **Active** | **Potential** | **Active and potential** | **Active** | **Potential** | **Active and potential** |
| 1999 |  |  |  | 14449 | 706 | 15155 |
| 2000 | 5177 | 230 | 5407 | 15598 | 1444 | 17042 |
| 2001 | 6114 | 313 | 6427 | 18193 | 3217 | 21410 |
| 2002 | 6674 | 425 | 7099 | 18238 | 4443 | 22681 |
| 2003 | 5809 | 159 | 5968 | 13292 | 6904 | 20196 |
| 2004 | 6833 | 965 | 7798 | 13511 | 11390 | 24901 |
| 2005 | 5640 | 1512 | 7152 | 11105 | 11582 | 22687 |
| 2006 | 3180 | 517 | 3697 | 5353 | 7930 | 13283 |
| 2007 | 4888 | 1047 | 5935 | 5091 | 6694 | 11785 |
| 2008 | 2203 | 31 | 2234 | 3504 | 2215 | 5719 |
| 2009 | 1994 | 421 | 2415 | 2480 | 2665 | 5145 |
| 2010 | 2050 | 578 | 2628 | 1973 | 2956 | 4929 |

Table : Fledging success

|  |  |  |
| --- | --- | --- |
|  | **Robben Island** | **Dassen Island** |
| **Year** | **Crawford (2006)** | **Barham** | **Wolfaardt (2008)** |
| **Chicks per pair per year** | **Fledges per nest[[1]](#footnote-1)** | **Chicks per nest per year[[2]](#footnote-2)** |
| 1989 | 0.415 |  |  |
| 1990 | 0.319 |  |  |
| 1991 | 0.592 |  |  |
| 1992 | 0.590 |  |  |
| 1993 | 0.535 |  |  |
| 1994 | 0.446 |  |  |
| 1995 | 0.383 |  | 0.825 |
| 1996 | 0.654 |  | 1.022 |
| 1997 | 0.968 |  | 1.180 |
| 1998 | 0.748 |  | 1.343 |
| 1999 | 0.600 |  | 1.376 |
| 2000 | 0.232 |  |  |
| 2001 |  | 0.756 |  |
| 2002 |  | 0.516 |  |
| 2003 |  | 0.449 |  |
| 2004 |  | 0.487 |  |
| 2005 |  | 0.811 |  |
| 2006 |  | 0.627 |  |
| 2007 |  | 1.142 |  |
| 2008 |  | 1.031 |  |
| 2009 |  | 0.937 | 1.060 |

Table : Fatalities as a direct result of major oil spills (Crawford *et al*. 1999, Crawford *et al*. 2000, Wolfaardt *et al*. 2009).

|  |  |  |  |
| --- | --- | --- | --- |
| **Vessel** | **Year** | **Adults** | **Chicks** |
|  |  | Robben  | Dassen | Robben  | Dassen |
| *Apollo Sea* | 1994 | 1200 | 4000 | 1300 | 4100 |
| *Treasure* | 2000 | 1500 | 500 | 3300 | 1080 |

Table : Annual pelagic catch taken within 15 nautical miles of Robben Island and Dassen Island (in tonnes), compiled by J. van der Westhuizen (2010).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** |  | **Robben** |  |  | **Dassen** |  |
| **Sardine** | **Achovy** | **Total** | **Sardine** | **Achovy** | **Total** |
| 1987 | 1577 | 34686 | 36263 | 5706 | 51526 | 57232 |
| 1988 | 2953 | 44734 | 47687 | 10026 | 33909 | 43935 |
| 1989 | 2395 | 30736 | 33131 | 4090 | 24990 | 29080 |
| 1990 | 5262 | 5130 | 10392 | 9961 | 8686 | 18647 |
| 1991 | 2880 | 15993 | 18873 | 4657 | 10433 | 15090 |
| 1992 | 4166 | 32012 | 36178 | 6677 | 42180 | 48857 |
| 1993 | 3526 | 7767 | 11293 | 9205 | 14977 | 24182 |
| 1994 | 4861 | 21589 | 26450 | 5674 | 29424 | 35098 |
| 1995 | 2777 | 9498 | 12275 | 10616 | 20223 | 30839 |
| 1996 | 5981 | 4243 | 10224 | 23849 | 7530 | 31379 |
| 1997 | 9523 | 7945 | 17468 | 7041 | 3463 | 10504 |
| 1998 | 9678 | 3252 | 12930 | 19455 | 2927 | 22382 |
| 1999 | 9275 | 17000 | 26275 | 25922 | 36286 | 62208 |
| 2000 | 2264 | 12908 | 15172 | 6441 | 30003 | 36444 |
| 2001 | 4029 | 12023 | 16052 | 6465 | 51926 | 58391 |
| 2002 | 19829 | 17397 | 37226 | 21152 | 36436 | 57588 |
| 2003 | 24511 | 30581 | 55092 | 16583 | 31338 | 47921 |
| 2004 | 2388 | 17925 | 20313 | 2543 | 25800 | 28343 |
| 2005 | 385 | 11046 | 11431 | 1679 | 56067 | 57746 |
| 2006 | 2455 | 21442 | 23897 | 3685 | 40325 | 44010 |
| 2007 | 1977 | 35374 | 37351 | 3912 | 39741 | 43653 |
| 2008 | 808 | 48139 | 48947 | 1977 | 13338 | 15315 |
| 2009 | 1409 | 33100 | 34509 | 330 | 3359 | 3689 |

Table : Pelagic hydroacoustic survey estimates (in millions of tonnes) (de Moor *et al*. 2008, with updates provided by C. de Moor and J. Coetzee). The November series comprises the aggregate adult biomass west of Cape Aguhlas. The May series comprises the total recruit biomass west of Cape Infanta. The year shown is the calendar year.

|  |  |  |
| --- | --- | --- |
|  | **November spawner biomass** | **May recruit biomass** |
| **Year** | **Sardine** | **Anchovy** | **Combined** | **Sardine** | **Anchovy** | **Combined** |
| 1984 | 0.048009 | 1.461636 | 1.509645 |  |  |  |
| 1985 | 0.025457 | 1.014215 | 1.039672 | 0.038265 | 0.368623 | 0.406888 |
| 1986 | 0.238230 | 1.978652 | 2.216883 | 0.050073 | 0.621089 | 0.671162 |
| 1987 | 0.094165 | 1.866430 | 1.960595 | 0.098643 | 0.721578 | 0.820220 |
| 1988 | 0.128043 | 1.289624 | 1.417668 | 0.005223 | 0.563107 | 0.568329 |
| 1989 | 0.198328 | 0.517293 | 0.715622 | 0.066081 | 0.173349 | 0.239430 |
| 1990 | 0.248855 | 0.342812 | 0.591667 | 0.031208 | 0.170083 | 0.201291 |
| 1991 | 0.517180 | 1.254359 | 1.771539 | 0.026665 | 0.528177 | 0.554842 |
| 1992 | 0.247756 | 1.036580 | 1.284337 | 0.074822 | 0.458455 | 0.533278 |
| 1993 | 0.480822 | 0.439121 | 0.919942 | 0.114956 | 0.481108 | 0.596064 |
| 1994 | 0.389730 | 0.309981 | 0.699711 | 0.072462 | 0.145336 | 0.217797 |
| 1995 | 0.348832 | 0.468678 | 0.817510 | 0.205149 | 0.392016 | 0.597164 |
| 1996 | 0.257763 | 0.029748 | 0.287511 | 0.073612 | 0.074842 | 0.148453 |
| 1997 | 0.964835 | 0.377663 | 1.342498 | 0.396718 | 0.404620 | 0.801338 |
| 1998 | 1.082547 | 0.206586 | 1.289132 | 0.134907 | 0.453210 | 0.588116 |
| 1999 | 0.708029 | 0.741961 | 1.449990 | 0.235720 | 0.826090 | 1.061810 |
| 2000 | 0.726230 | 1.960122 | 2.686351 | 0.299473 | 2.553502 | 2.852975 |
| 2001 | 0.669617 | 2.301999 | 2.971617 | 0.573427 | 1.998427 | 2.571854 |
| 2002 | 1.184713 | 2.018570 | 3.203283 | 0.616331 | 1.560101 | 2.176432 |
| 2003 | 1.343118 | 1.181111 | 2.524229 | 0.600667 | 1.434900 | 2.035567 |
| 2004 | 0.292522 | 0.736973 | 1.029495 | 0.040419 | 1.071419 | 1.111838 |
| 2005 | 0.075604 | 0.670730 | 0.746334 | 0.011236 | 0.560518 | 0.571754 |
| 2006 | 0.177885 | 1.027009 | 1.204894 | 0.050394 | 0.275797 | 0.326191 |
| 2007 | 0.057666 | 0.889676 | 0.947342 | 0.034575 | 1.534523 | 1.569099 |
| 2008 | 0.211871 | 1.421593 | 1.633464 | 0.024461 | 1.491847 | 1.516308 |
| 2009 | 0.262853 | 2.098253 | 2.361106 | 0.063468 | 1.317059 | 1.380527 |
| 2010 |  |  |  | 0.499986 | 1.687118 | 2.187104 |

1. These data exclude *Treasure* oiled birds which are known to have had significantly lower breeding success. These data include nests where observations started at chick, rather than egg, stages. Double clutches are included and treated as separate nests. [↑](#footnote-ref-1)
2. Recorded values (chicks per pair) were multiplied by a factor of 1.27 to account for some pairs laying a second clutch in one season. This should make this series comparable with the Crawford series for Robben Island. [↑](#footnote-ref-2)